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Using the DesignSafe Cyberinfrastructure to Improve Resilience Against Natural Hazards

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Dept. of Civil, Arch., and Env. Engineering
University of Texas at Austin

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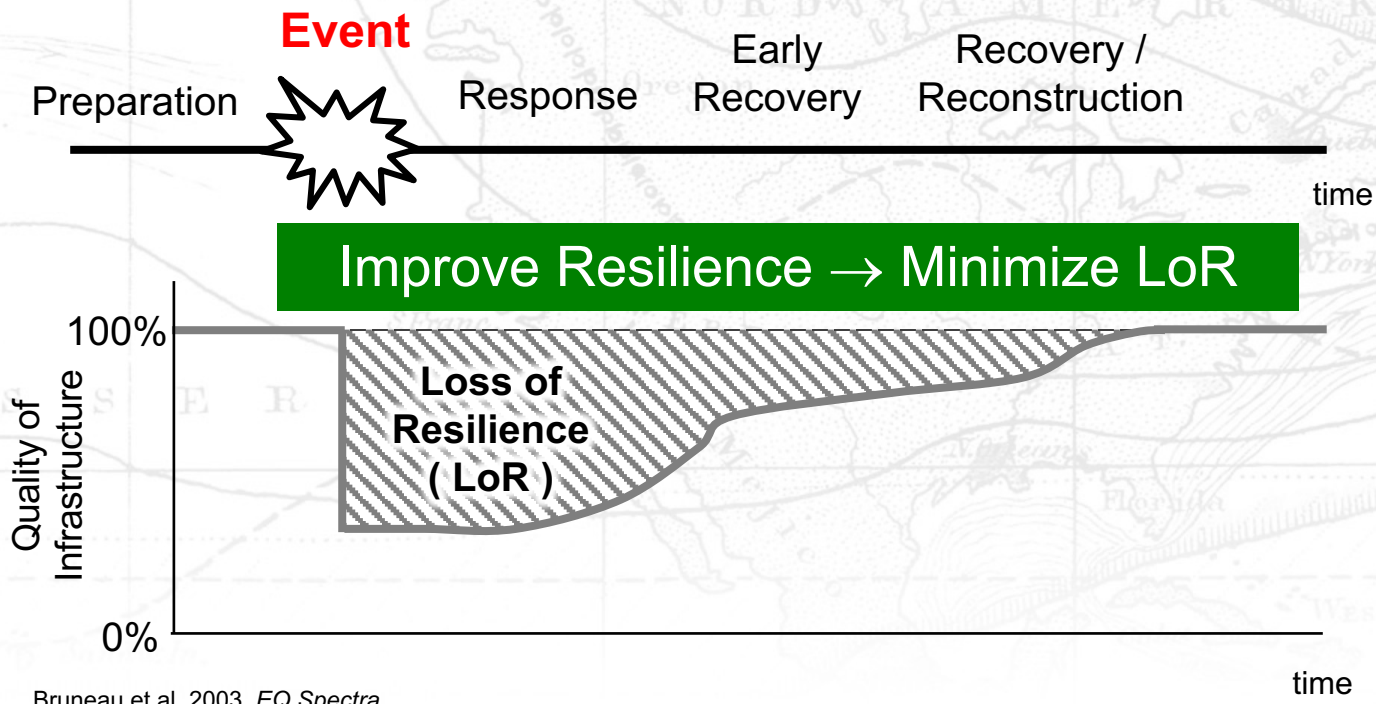
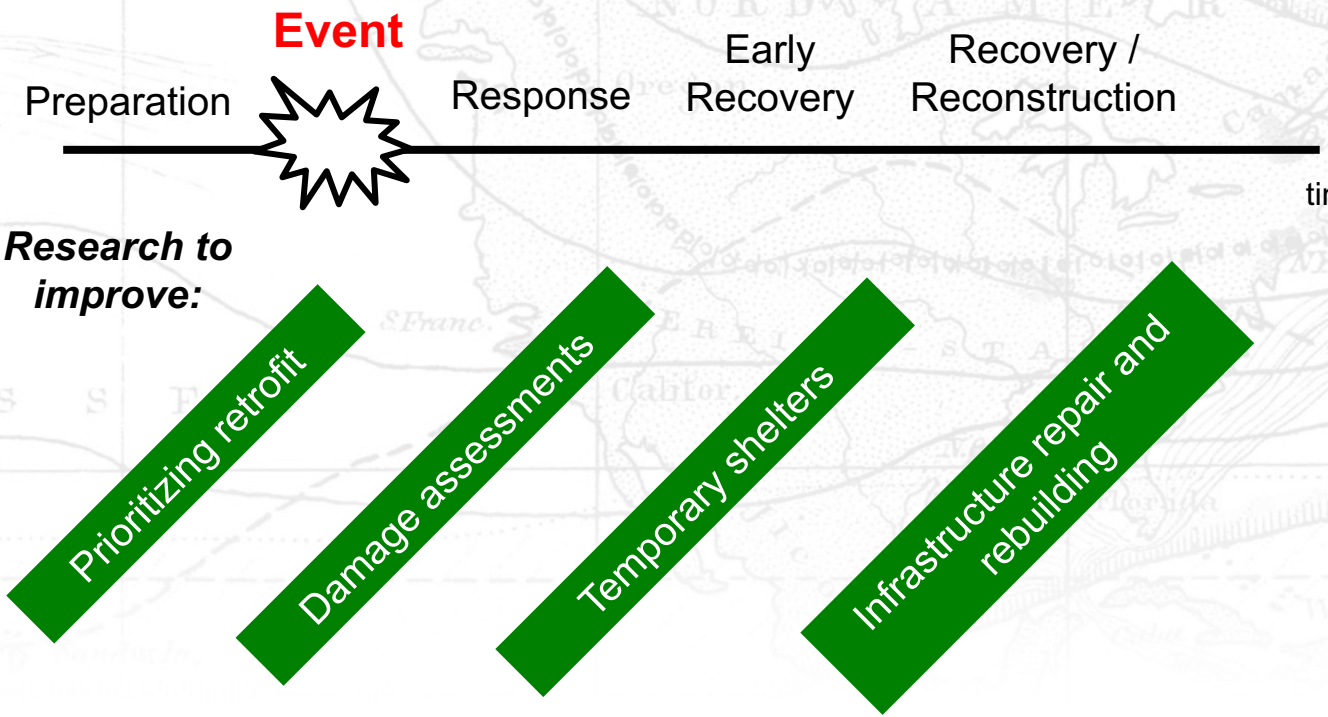
Disaster Resilience



Bruneau et al. 2003, *EQ Spectra*

Improving Resilience



Improving Resilience-Impediments

- Limited availability of data
  - Damaging effects of previous disasters and the resulting response/recovery/rebuilding
  - Experimental data investigating engineering solutions
  - Simulation data predicting effects of natural hazards
- Why is little data available?
  - Researchers may collect data but do not share it broadly
  - After data are used by a researcher, it is “filed away”
  - No mechanism to reward data sharing

Improving Resilience-Impediments

- Integrating diverse datasets is cumbersome
  - Data sets from different fields are found in different places
  - Large data sets are hard to move
  - Visualization is often needed

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What is DesignSafe?

- A web-based research platform that provides tools to manage, analyze, and understand critical data for natural hazards research

DesignSafe Vision

- A cyberinfrastructure (CI) that is an integral part of research discovery
  - Provide a platform for data sharing/publishing
  - Enable research workflows and access to high performance computing (HPC)
  - Deliver cloud-based tools that support the analysis, visualization, and integration of diverse data types
- Amplify and link the capabilities of natural hazards researchers in the US and abroad

NHERI Natural Hazards Engineering Research Infrastructure

- DesignSafe cyberinfrastructure
- Seven experimental facilities
- RAPID reconnaissance facility
- Computational modeling and simulation center (SimCenter)
- Coordinating Office (NCO)

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NHERI: A NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE

www.designsafe-ci.org

Research Workbench ▾ | Learning Center ▾ | NHERI Facilities ▾ | NHERI Community ▾ | About | Help ▾ | Search DesignSafe

- Data Depot
- Workspace
- Recon Portal
- SimCenter Research Tools
- User Guides

D…sed research pl…twork that pr…al tools needed to m…derstand critical d…esearch.

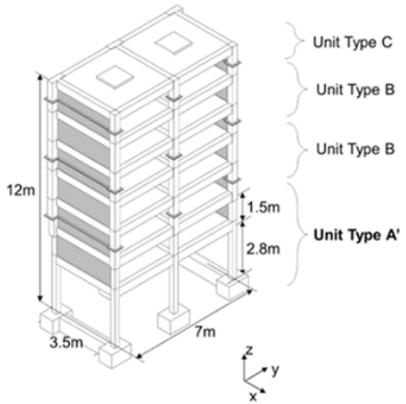
Learn how to
Start Using DesignSafe

Browse the Data Depot's
Published Data Sets

Join the conversation in
DesignSafe's Slack Channel

Learn more about
NHERI, the NCO & DesignSafe

NHERI Five-Year Science Plan



QuakeCoRE

NCREE

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3-D and first storey plan view of test specimens

QuakeCoRE/NCREE Blind Prediction Competition

The QuakeCoRE center in New Zealand, in collaboration with the National Centre for Research on Earthquake Engineering (NCREE) in Taiwan and DesignSafe in the US, is excited to announce a competition to predict the response of reinforced concrete (RC) structures with torsional irregularities to earthquake shaking. Expressions of interest are due by 5 pm on May 01, 2019 (New Zealand time).

FIND MORE NEWS IN THE NEWSROOM

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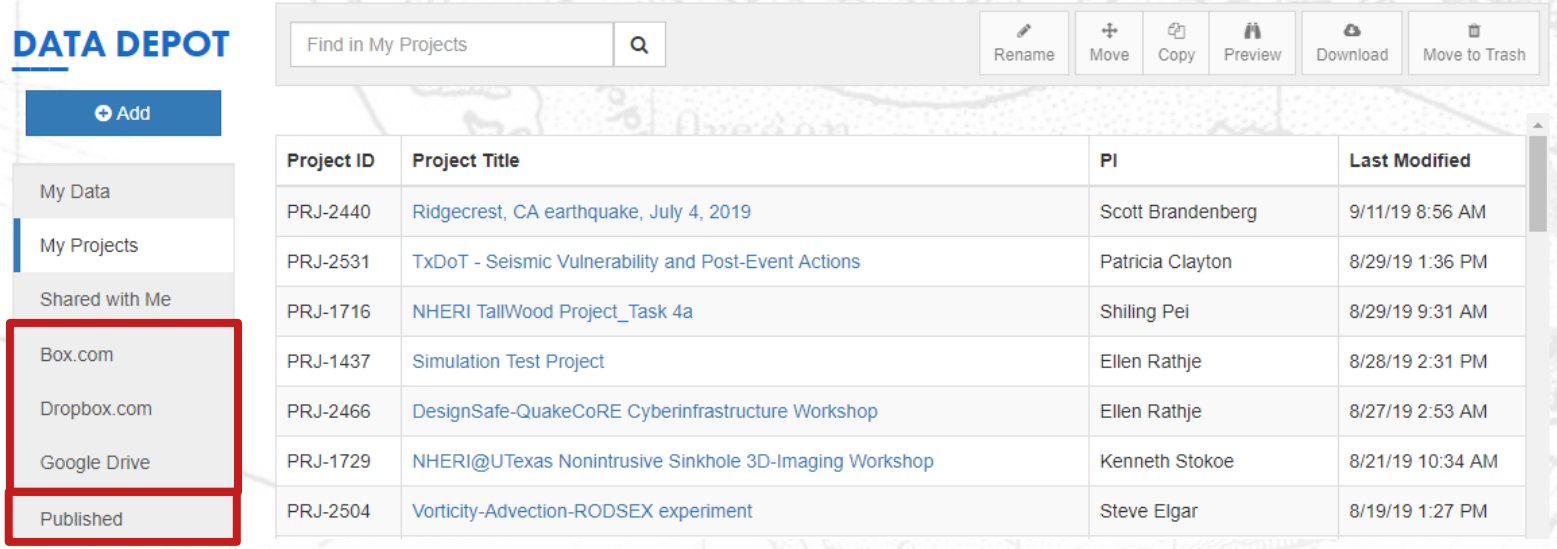
DesignSafe Research Workbench

- Data Depot Data Repository
  - Private space (My Data)
  - Collaboration space (My Projects) for data sharing and ultimate publishing
  - Publicly accessible space (Published) for curated data from My Projects
  - Publicly accessible space (Community Data) for uncurated data
- Discovery Workspace
  - Apps/tools for computational simulation, data analysis, etc. with access to files in Data Depot
- Reconnaissance Portal: discover published reconnaissance data
- SimCenter Research Tools: advanced simulation tools

Data Depot: My Projects



A space to share files/data/results with collaborators and to <u>eventually</u> publish for public use

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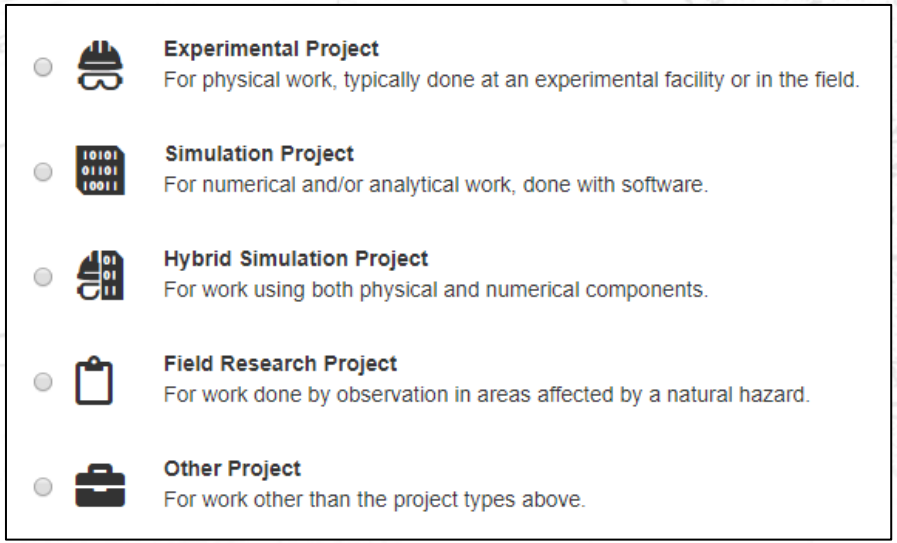
Data Curation Philosophy

- Allow users to easily store, share, document, and publish data throughout the life of a research project
- Flexible data models and interactive curation
  - Allows researchers to decide how to represent their research
  - Support different types of data
  - Consider what is needed for data to be understandable by others for data reuse

DesignSafe Data Models

Structured, yet flexible, data models for different types of research



Curation

- Define categories
- Assign files/folders to categories
- Relate categories to organize data

Curation Process

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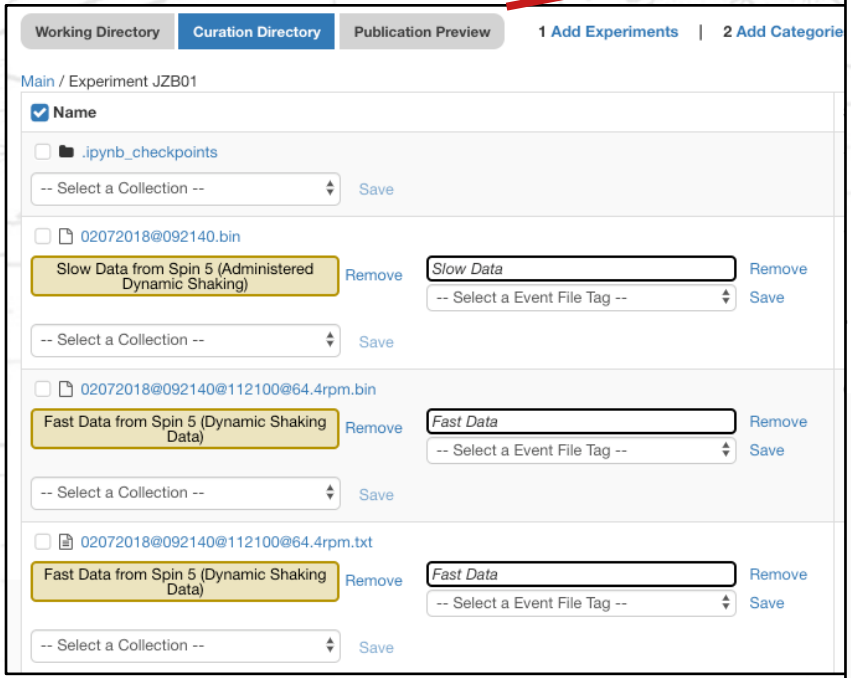
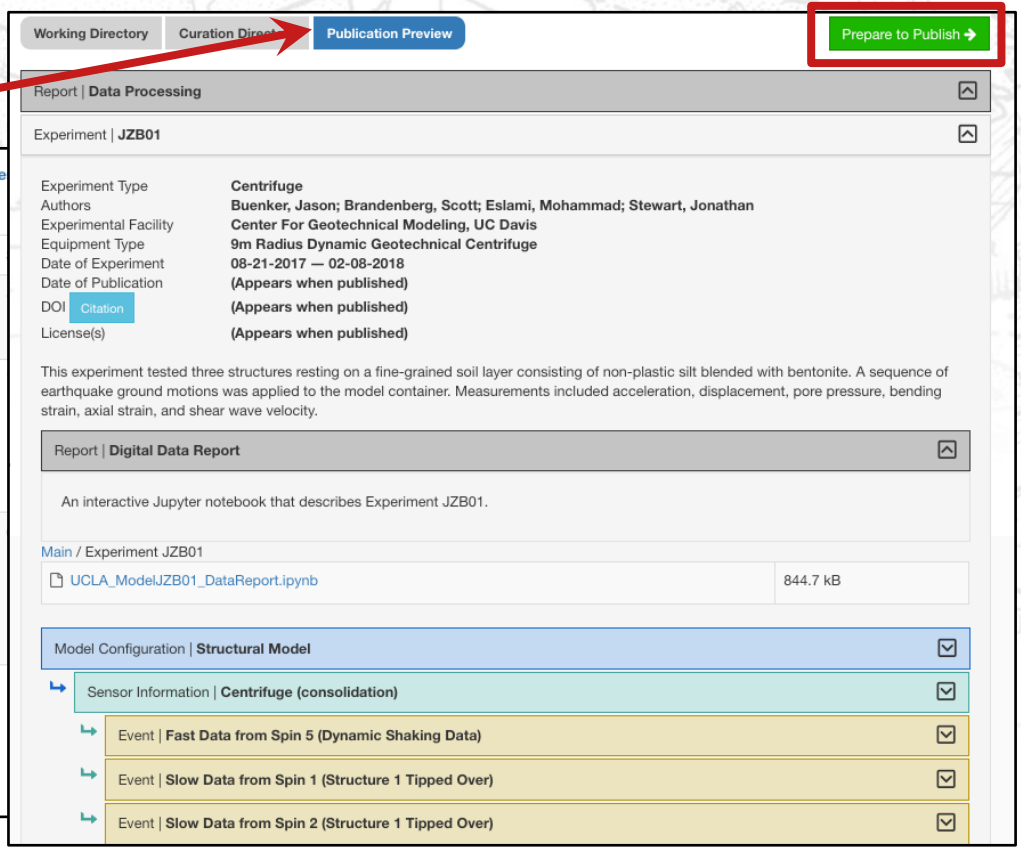
Curation Process





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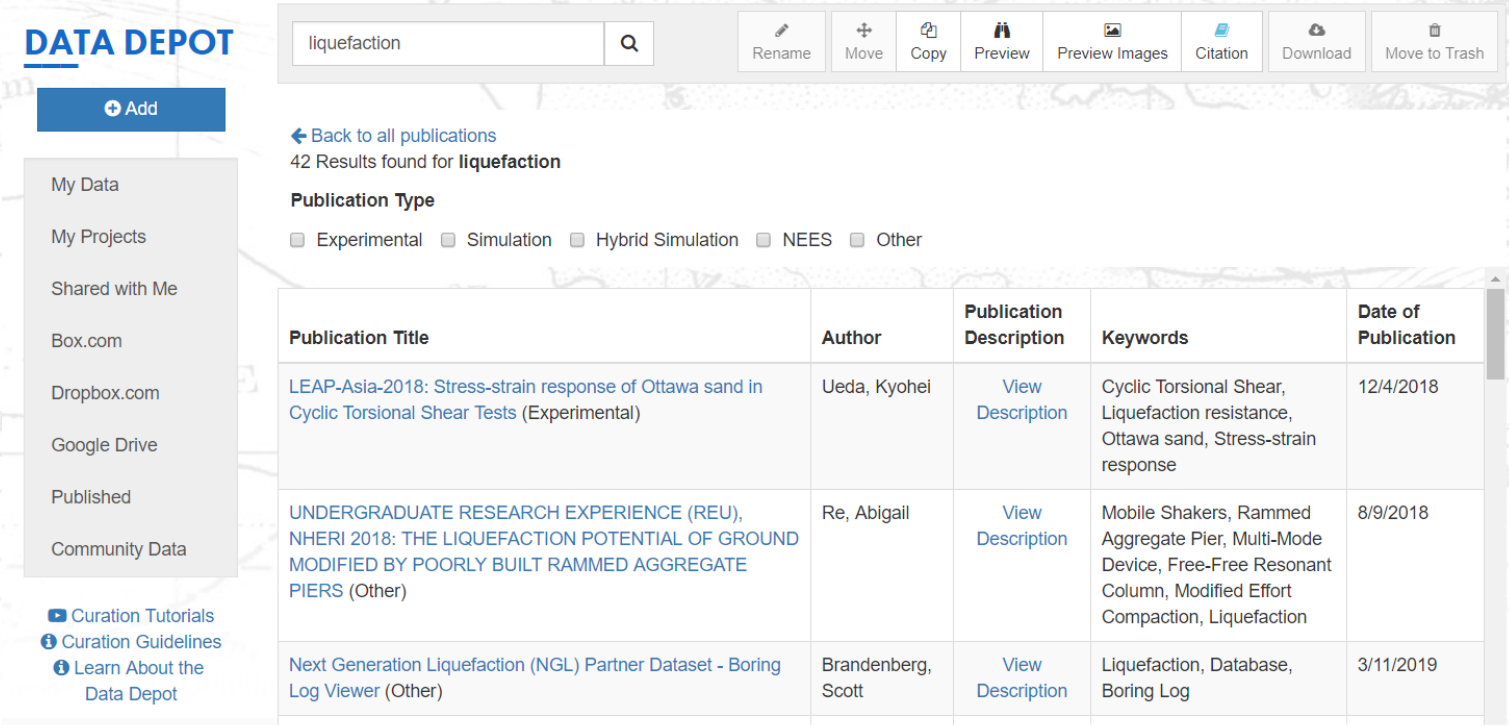
Data Depot Search



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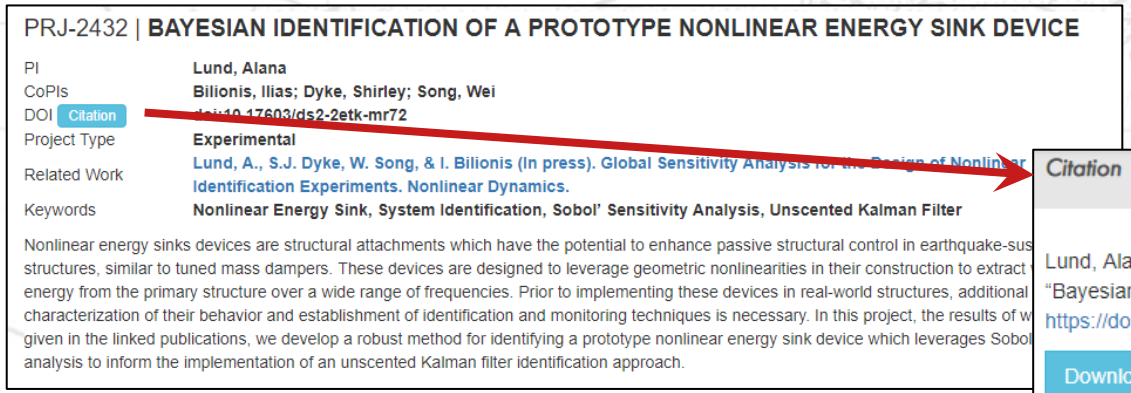
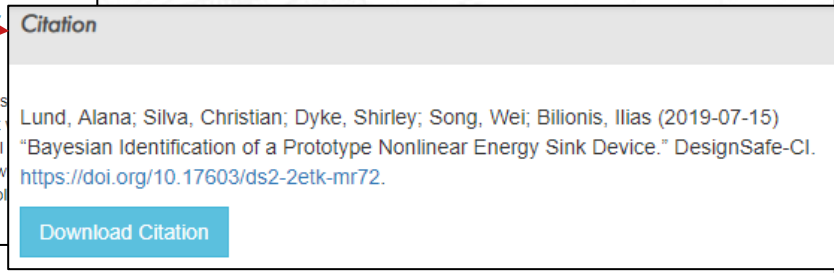
Make **your** data count!

- ***Formally publish*** data sets in stable data repositories
  - Include data processing scripts, visualizations, etc.
- Data needs a permanent, ***digital location (DOI)*** not just a URL
  - List curated data sets on your CV
- Formally cite data ***in your reference list*** of your papers using DOI, citation language as indicated in DesignSafe





Reconnaissance Portal

Identifying Archived Datasets from Recon Events

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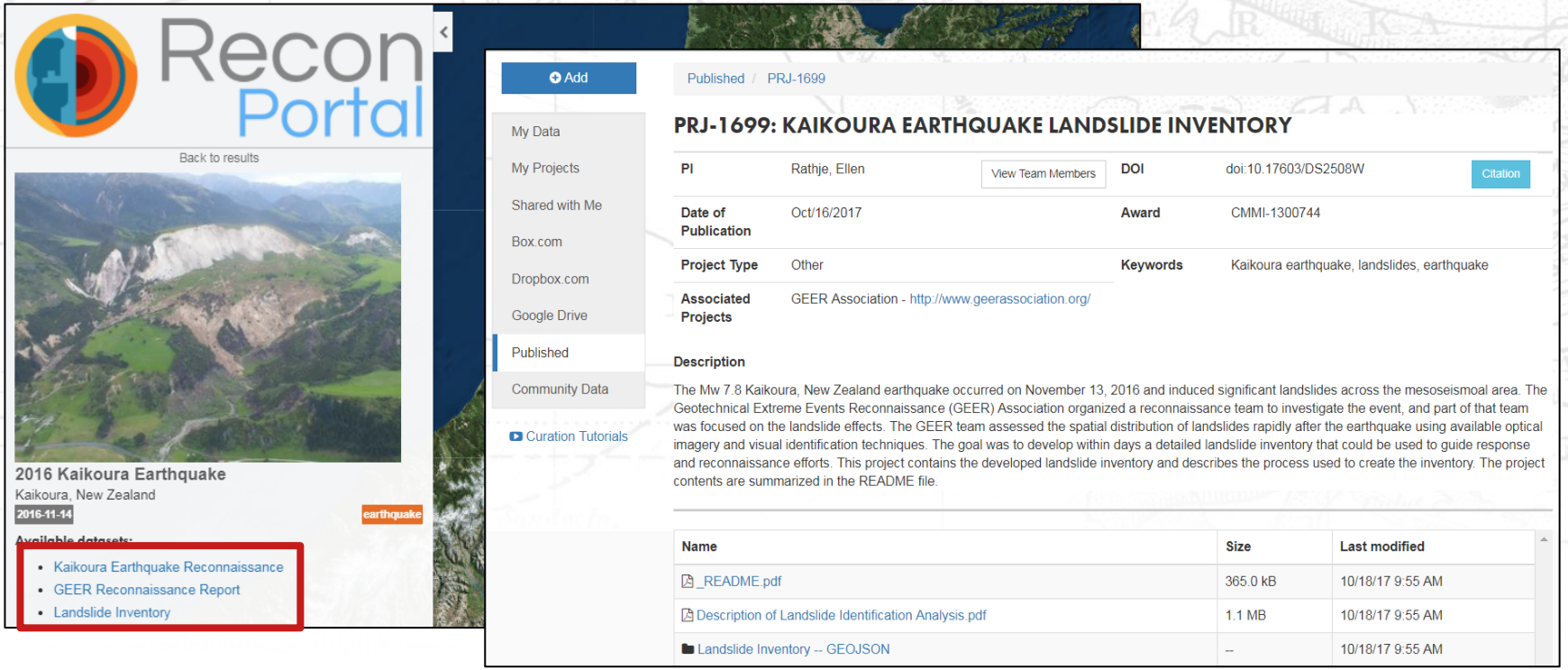
Recon Portal → Data Depot



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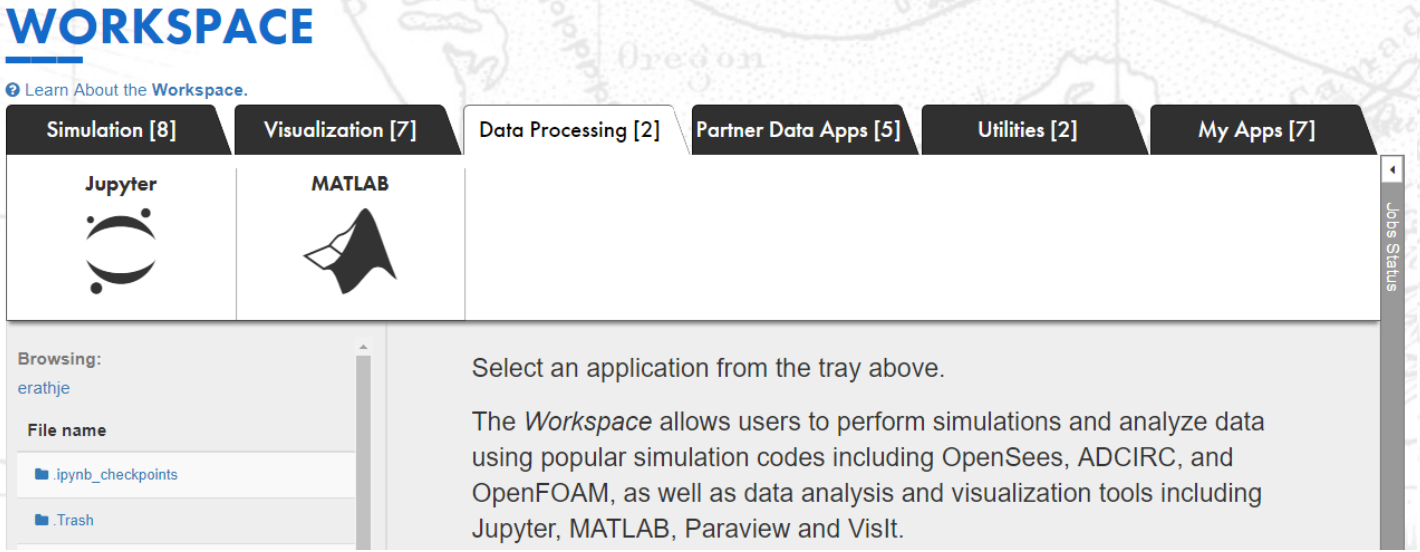
Discovery Workspace

- Cloud-based tools and HPC enabled codes (Stampede2)
- Access to files in the Data Depot



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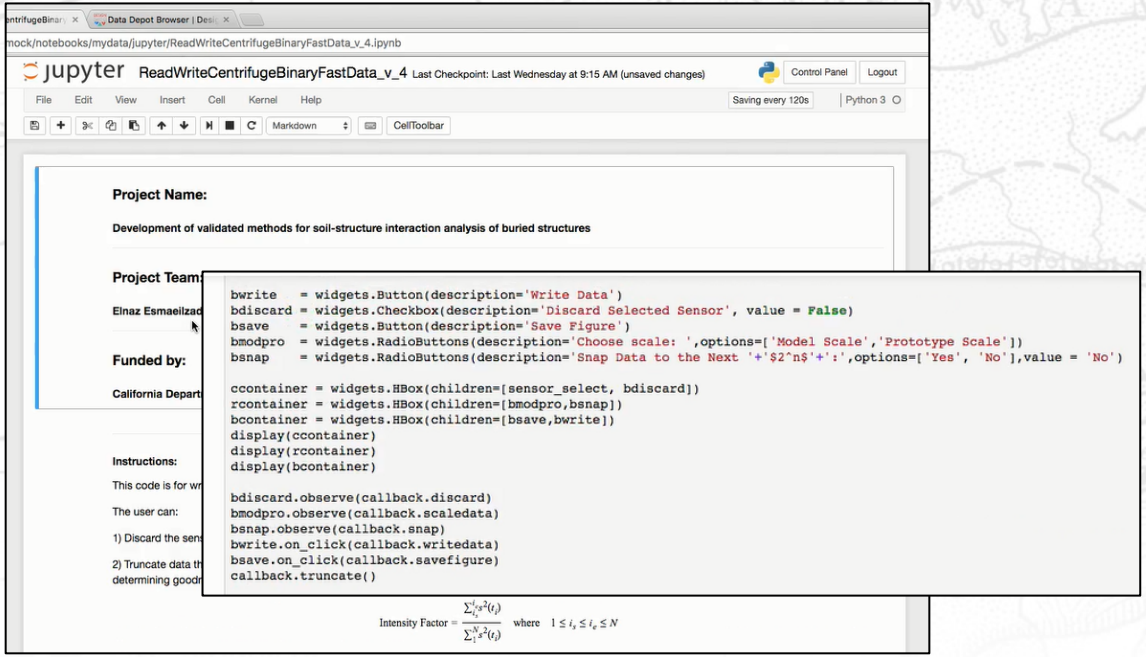
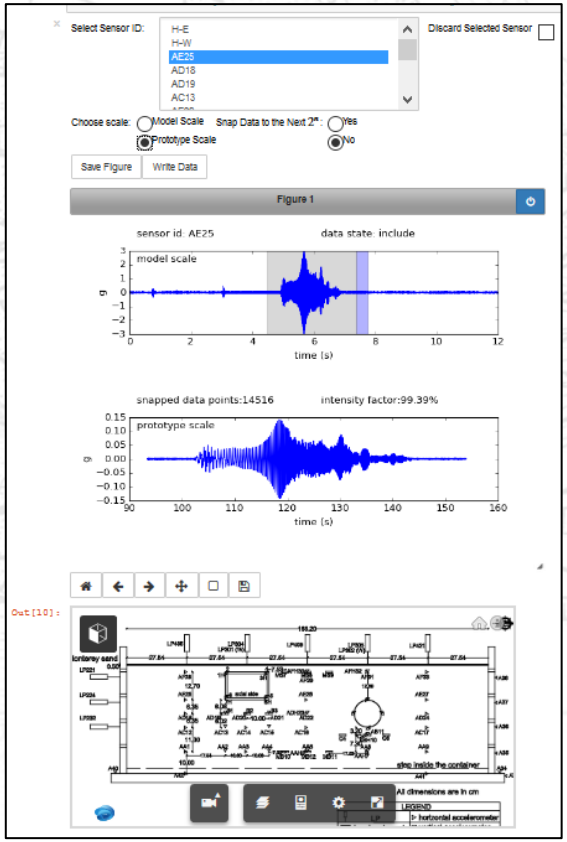
DesignSafe Discovery Workspace

- Data analysis in the cloud
  - Matlab: data analysis and plots, batch processing
  - Jupyter: electronic notebook that supports Python and R analysis
- Visualization
  - HazMapper: DesignSafe version of “Google Maps”
  - Potree: Create, view, and analyze point cloud data
  - QGIS: geospatial data analysis
  - Kalpana and FigureGen: data converter and plot generation for ADCIRC storm surge outputs

Electronic Notebook





From Prof. S. Brandenberg, UCLA

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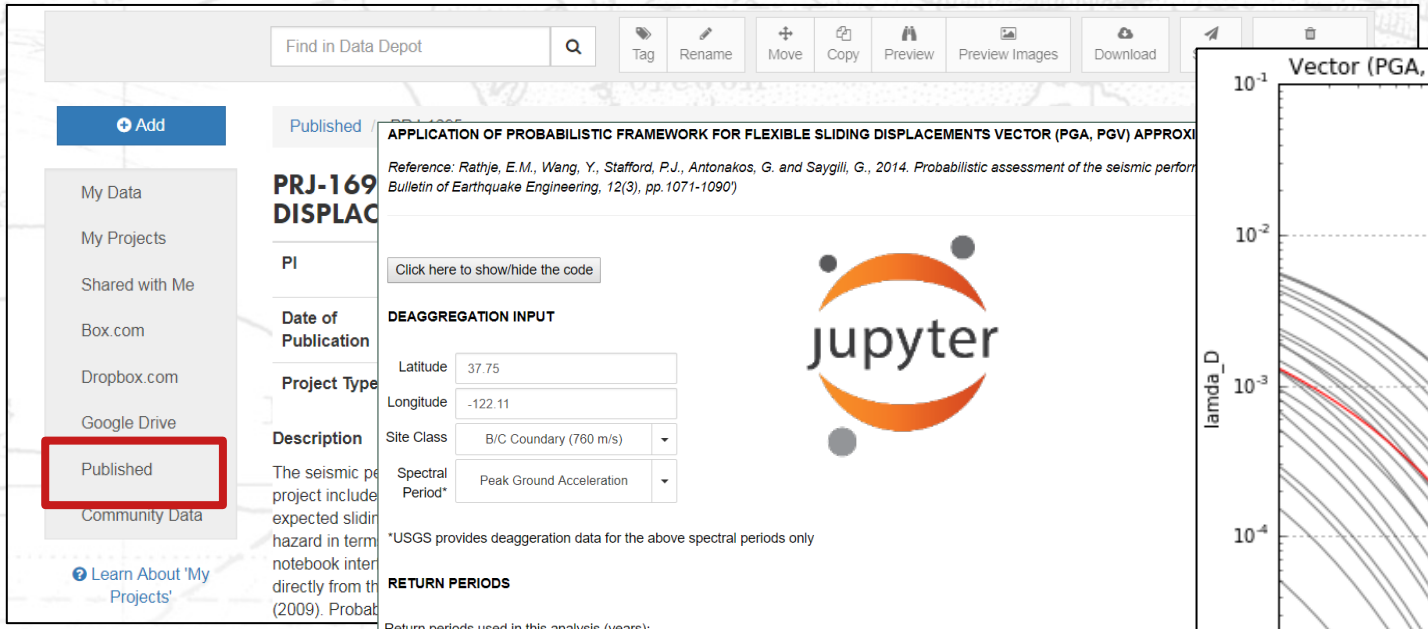
Published Scripts to Aid Research to Practice



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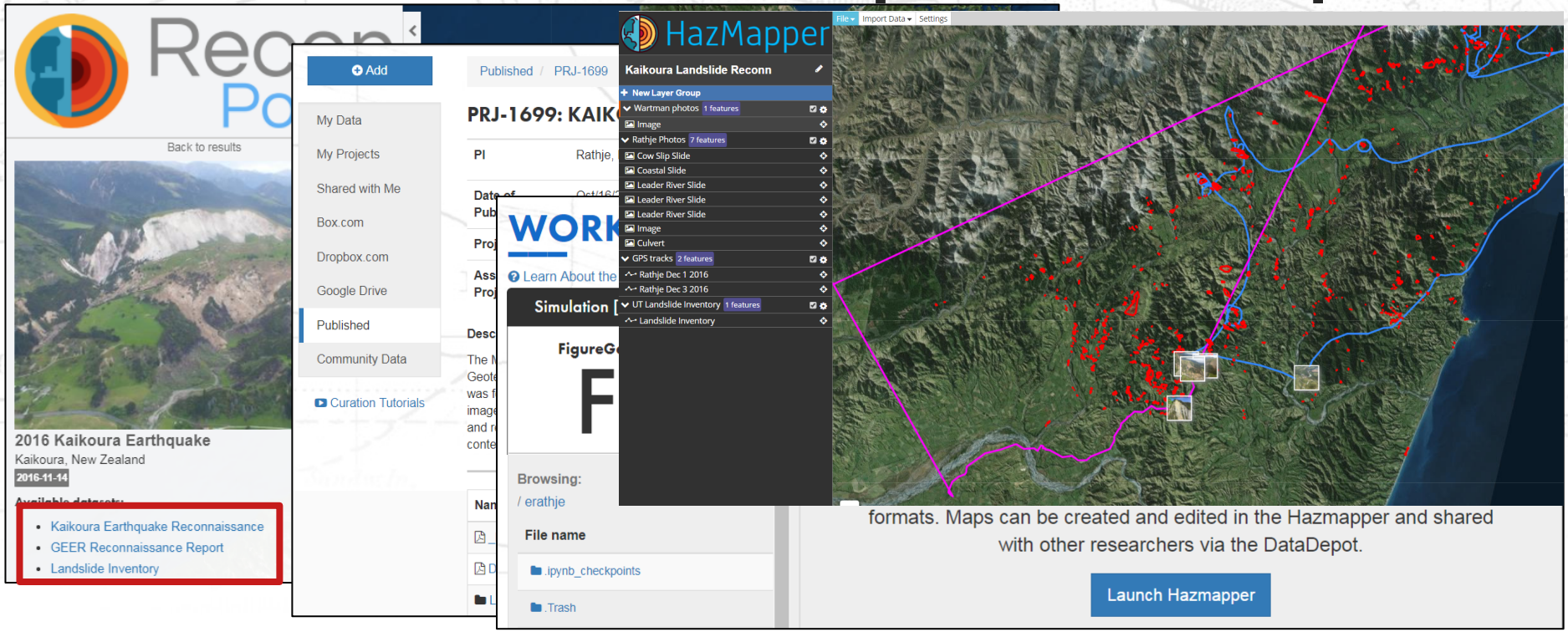
Recon Portal → Data Depot → Workspace



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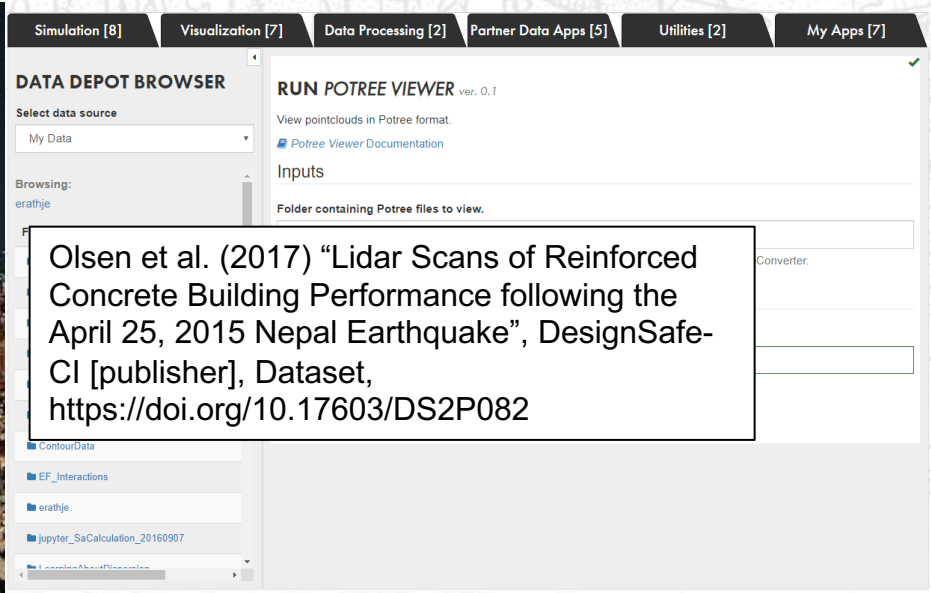
Potree Point Cloud Viewer



Olsen et al. (2017) “Lidar Scans of Reinforced Concrete Building Performance following the April 25, 2015 Nepal Earthquake”, DesignSafe-CI [publisher], Dataset, https://doi.org/10.17603/DS2P082

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Computational Simulation Codes

- OpenSees: FE code for seismic analysis of structures and soil
  - OpenSees Express: runs on a virtual machine
  - OpenSees MP and SP: run on Stampede2
  - Python interpreter for OpenSees available through Jupyter
- **Coming soon!**
  - STKO (Scientific Tool Kit for OpenSees): pre/post processing
- LS-Dyna: Commercial FE code for structures and soil
  - “Bring Your Own License”, submit a ticket to get access
  - Runs on Stampede2

Computational Simulation Codes

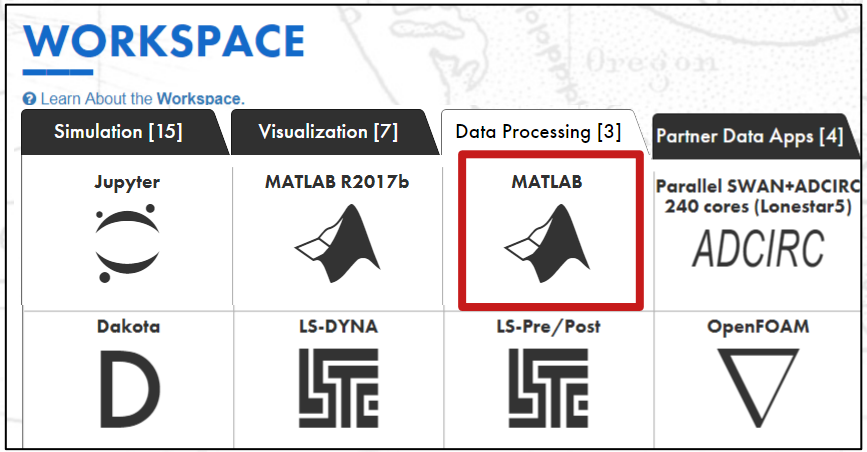
- ADCIRC: storm surge modeling
  - ADCIRC: serial version
  - PADCIRC: parallel version on Stampede2 and Lonestar5
  - PADCIRC + SWAN: includes near shore waves
  - Kalpana available to convert NetCDF to Shapefiles
  - FigureGen available to create images of ADCIRC output
- OpenFOAM: computational fluid dynamics
- Clawpack/GeoClaw: PDE solver for storm surge modeling

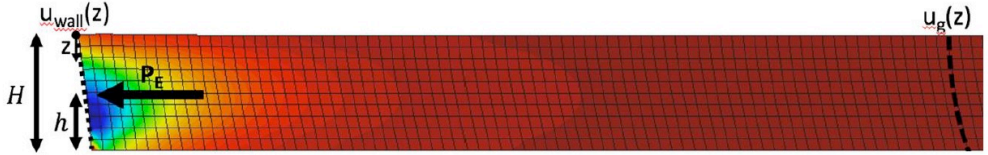
Access to Command Line (CLI)

- HPC-enabled simulation codes in the Workspace lowers the bar to researchers trying to access HPC
- All of these simulation codes are also available from the Command Line
  - Requires HPC allocation through DesignSafe
  - https://www.designsafe-ci.org/rw/user-guides/allocations-policy/
- Codes can also be accessed through Jupyter
  - Requires knowledge of Agave API

OpenSees Workflow Example

Seismic Earth Pressures on Retaining Walls





30,000 analysis parametric study

↓

Output files saved to Data Depot

↓

Post-processed in DesignSafe using matlab script

Durante et al. (2018) GEESD V, Austin, TX

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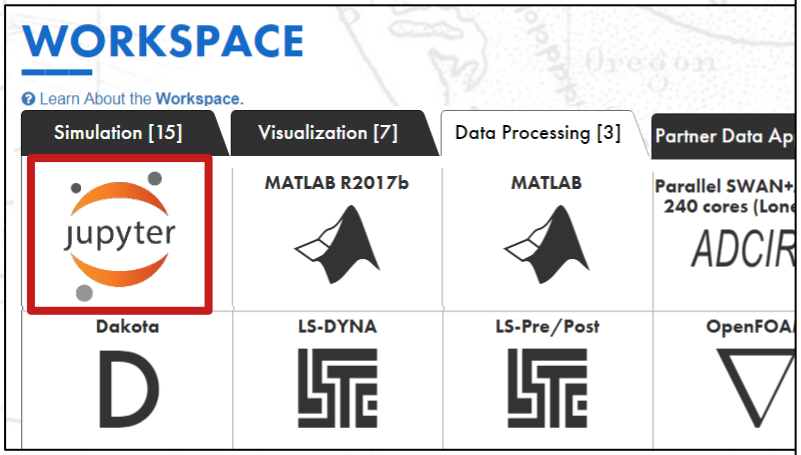
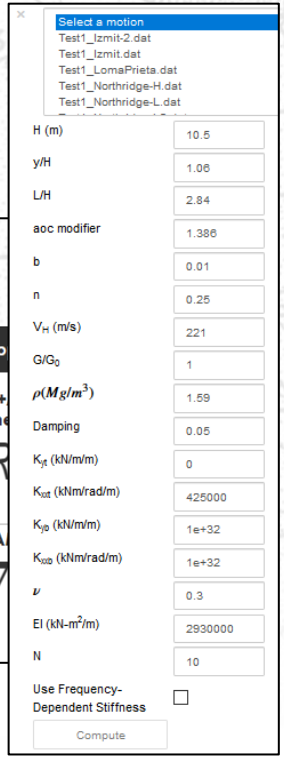
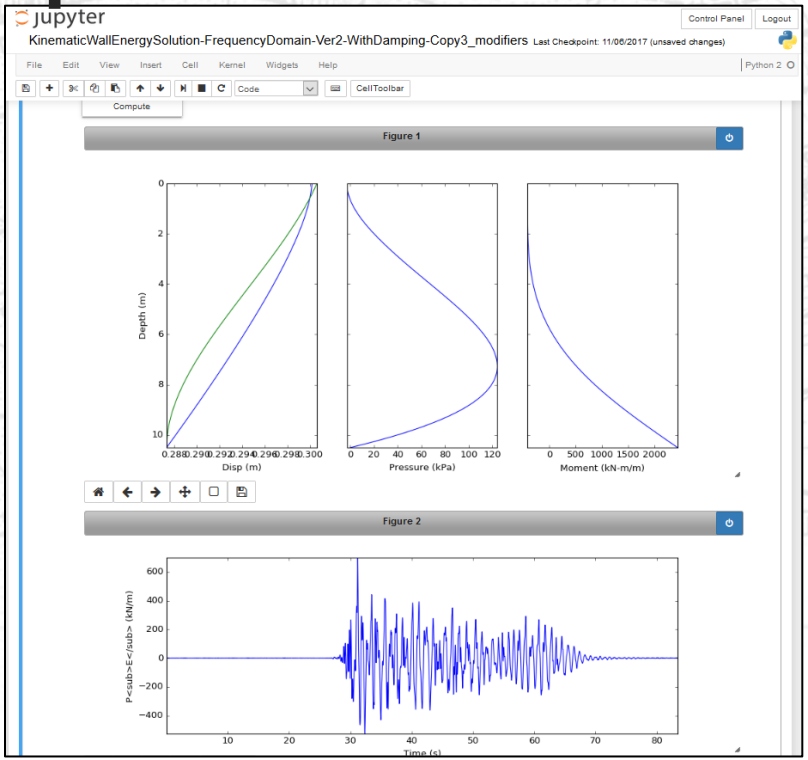
OpenSees Workflow Example

Develop analytical expressions to predict earth pressure from input time history and model properties







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ADCIRC Workflow Example

What addresses will be inundated on Galveston Island by storm surge from the impending hurricane?

- Compute storm surge water levels with ADCIRC
- Convert NetCDF output to shapefile format
- Import results into a QGIS along with elevation and property data
- Identify addresses that are inundated by simulated water levels

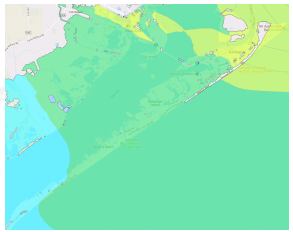
WORKSPACE

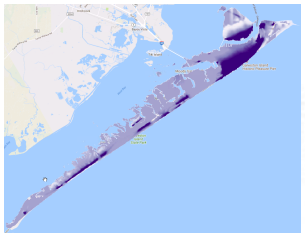
Learn About the **Workspace**.

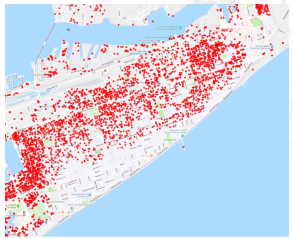
Simulation [8]	Visualization [7]	Data Processing [2]	Partner Data Apps [5]	Utilities [2]	My Apps [7]
ADCIRC	clawpack	Dakota	LS-DYNA	OpenFOAM	OpenSees

Simulation [8]	Visualization [7]	Data Processing [2]	Partner Data Apps [5]	Utilities [2]	My Apps [7]
FigureGen	Hazmapper	Kalpana	Paraview	Potree Converter	Potree Viewer
QGIS					

- Output placed in My Data
- Shapefile conversion performed using Kalpana
- Data integration and analysis in QGIS







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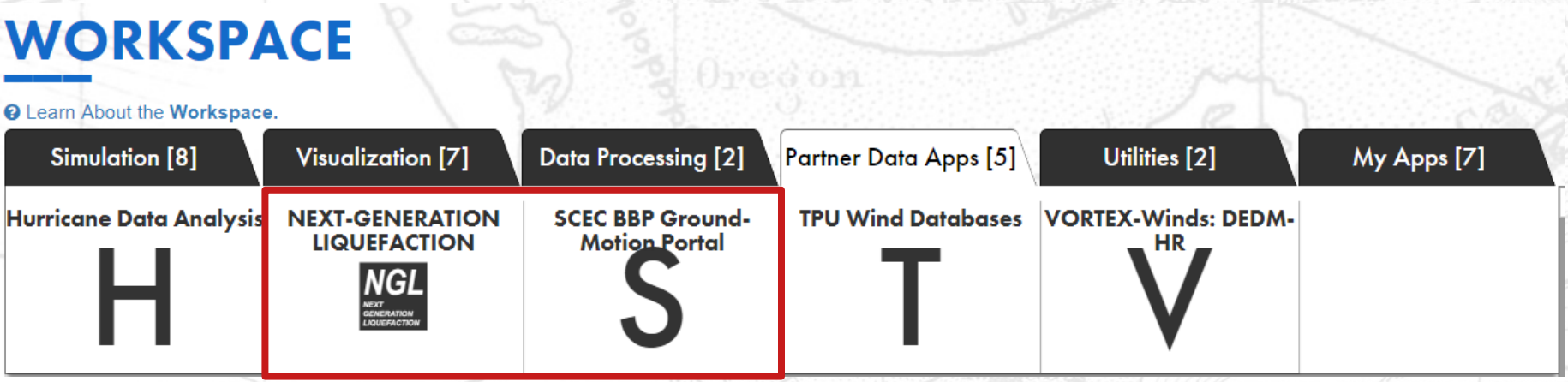
Partner Data Apps

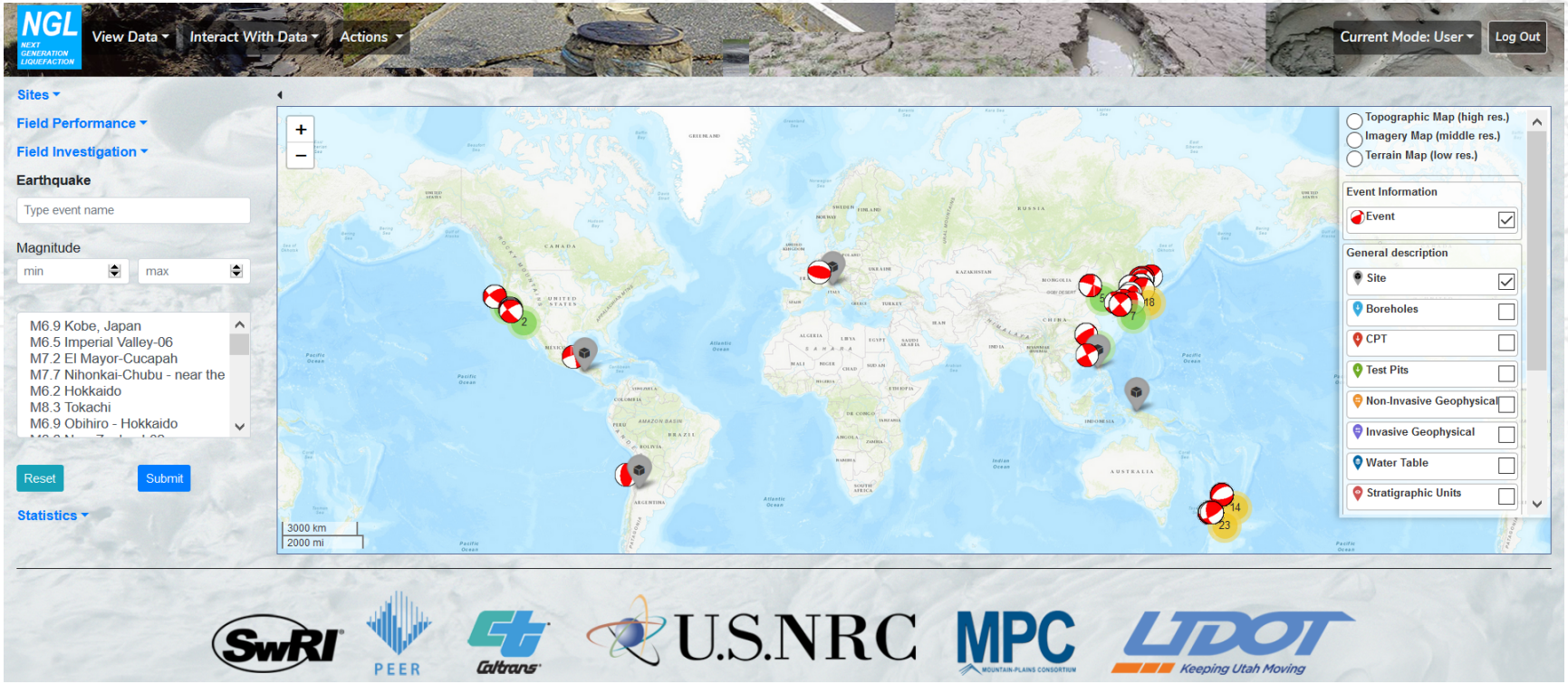


- Jupyter-based tools to access archived datasets
- Archived webinar from February 27, 2019

Next Generation Liquefaction (NGL)

www.nextgenerationliquefaction.org

- Community database of liquefaction case histories

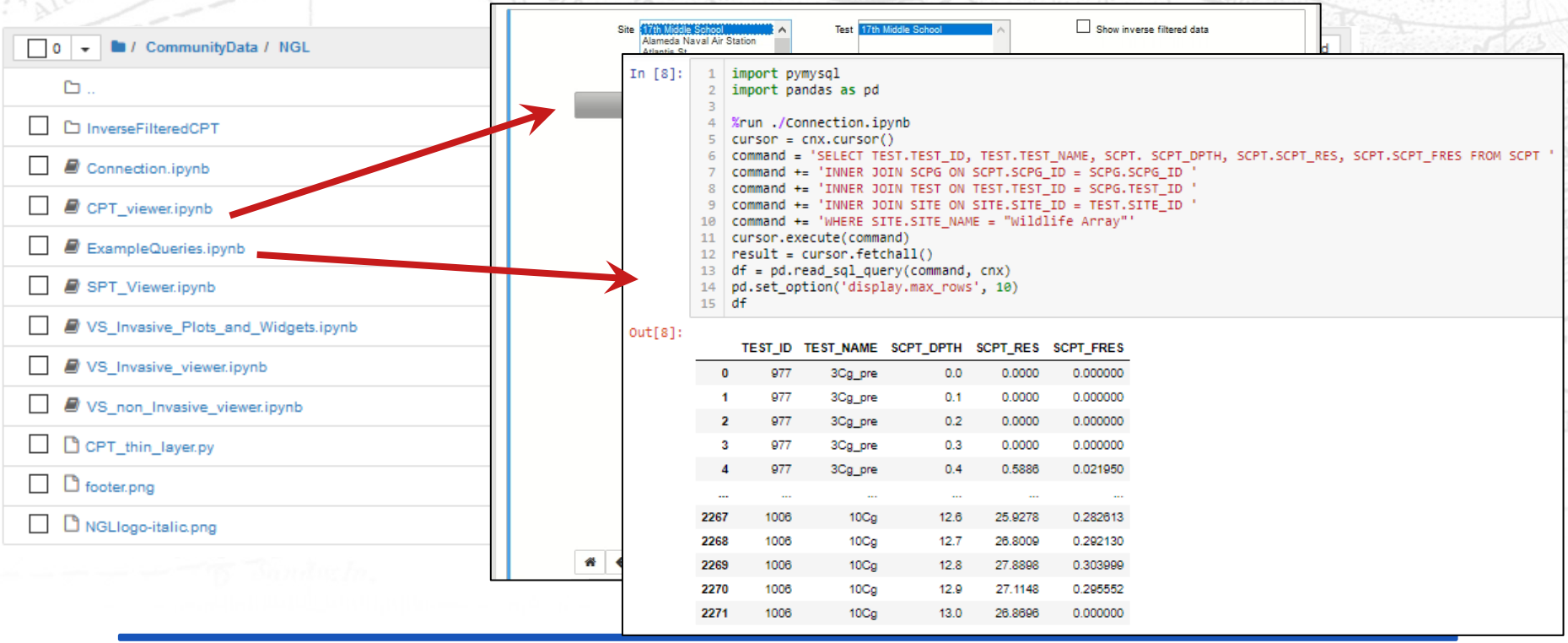


Next Generation Liquefaction (NGL)

- Data housed in SQL database
  - http://nextgenerationliquefaction.org/schema/index.html
- Database replicated to DesignSafe daily
- Jupyter notebooks to access data available in DesignSafe

From P. Zimmaro, UCLA

NGL Jupyter Notebooks



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0	977	3Cg_pre	0.0	0.0000	0.000000
1	977	3Cg_pre	0.1	0.0000	0.000000
2	977	3Cg_pre	0.2	0.0000	0.000000
3	977	3Cg_pre	0.3	0.0000	0.000000
4	977	3Cg_pre	0.4	0.5886	0.021950
...	...	...	...	...	...
2267	1006	10Cg	12.6	25.9278	0.282613
2268	1006	10Cg	12.7	26.8009	0.292130
2269	1006	10Cg	12.8	27.8898	0.303999
2270	1006	10Cg	12.9	27.1148	0.295552
2271	1006	10Cg	13.0	26.8696	0.000000

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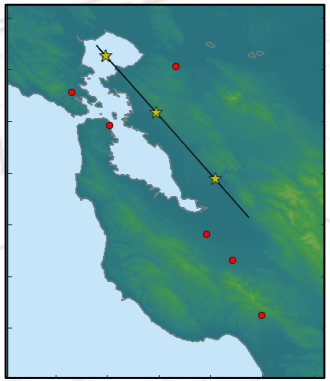
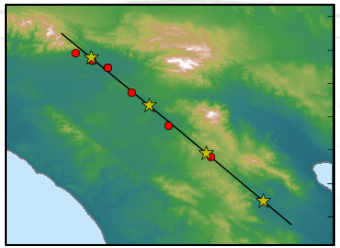
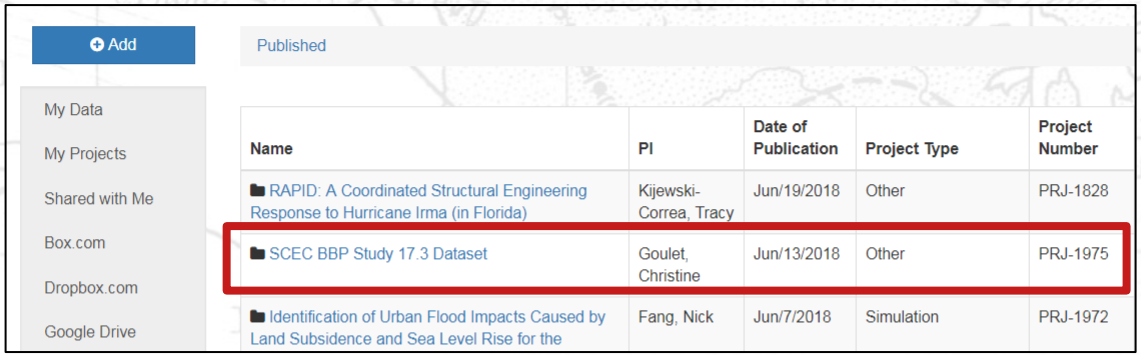
Broadband ground motion simulations





- SCEC Broadband Platform Dataset 17.3
  - Simulations for design levels events in NoCal and SoCal
  - Time series published as a DesignSafe data set
  - Jupyter notebook tool to search and select motions



SCEC BBP Ground Motion Portal

jupyter Run_me Last Chec

File Edit View Insert Cell

In [1]: %run ./SCEC_BBP_GMport

SCEC BBP

The SCEC Broadband Platf
historical and scenario earth
alternative computational me
The goal of the SCEC Broad
motions for earthquakes. Th
project involving SCEC rese
software development group
Platform including rupture ge
site effects, and visualizatio
seismograms. The SCEC Br
motion simulations. More ca

Dataset: SCEC_BBP_Simulation_Study_17_3_180614

SEARCH CRITERIA

the Dataset contains 2074 records

Earthquake Magnitude (Range:6.6-8.0):

Mmin 7

Mmax 7.5

Rjb Dis

Rjb

Rjbr

Intensity Measure:

Include Yes No

IM: PSA_RotD50_D0pt

Period: 0.010

Search Clear Output

SAVE SEARCH RESULTS

OneWord_SearchFolderName

Allo

No

Save Data

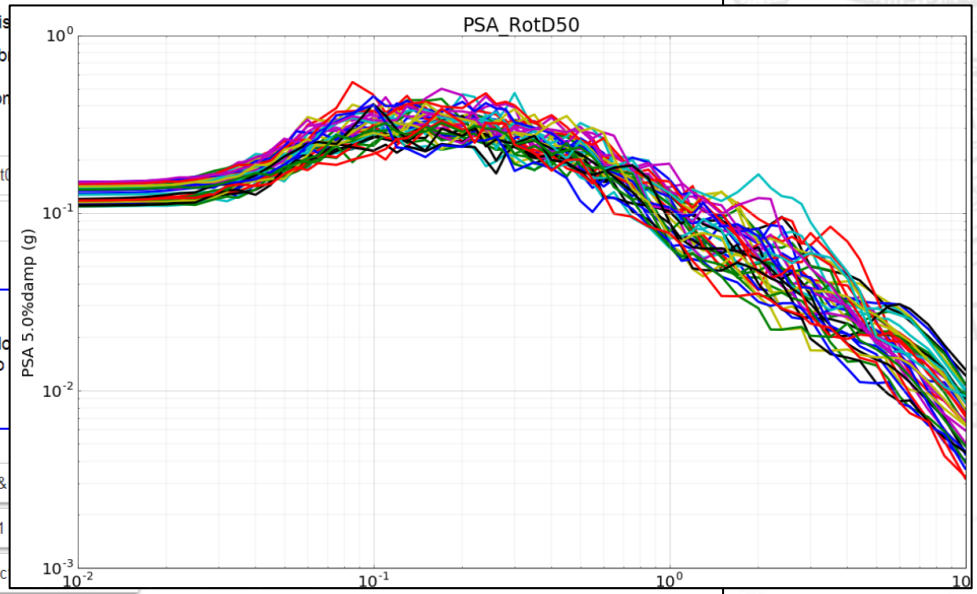
VISUALIZATION OF RESULTS

RotD50 Spectra Plot | RotD100 Spectra Plot | H1 &

RotD50 Spectra Table | RotD100 Spectra Table | H1

Metadata Table | FileData Table | Spec

Select Record To Visualize: Select Filename



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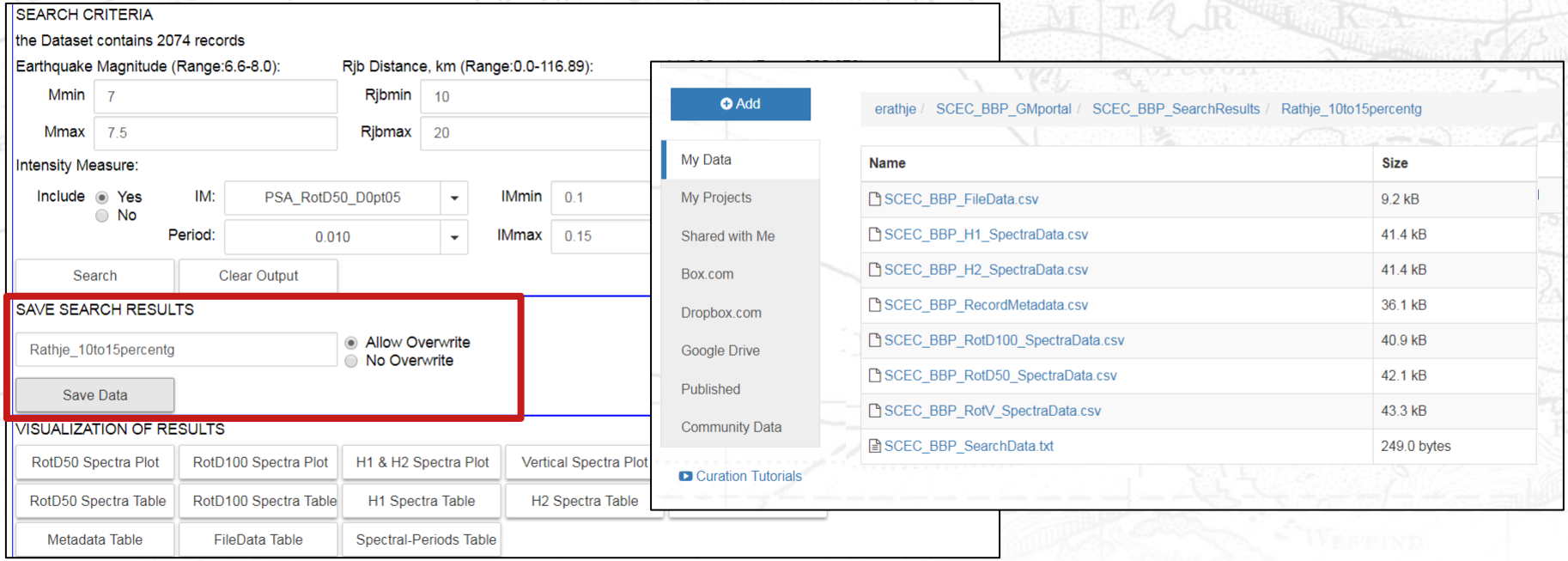
SCEC BBP Ground Motion Portal



DESIGNSAFE-CI A NATURAL HAZARDS ENGINEERING COMMUNITY

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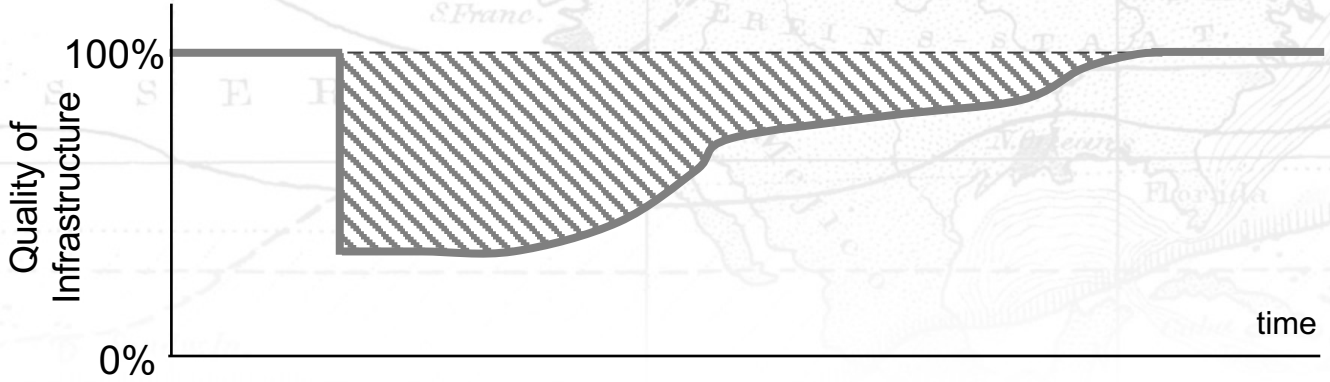
DesignSafe: Open for Business

- Capabilities available to the global natural hazards research community
  → account registration is free
- Working to expand our reach
  - Social science/urban planning/health care; earth science; AI/ML



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